throw out the factors $\vartheta^2, \vartheta, \vartheta, \vartheta$, thus arriving at a result independent of (λ, μ, ν); viz. this is the before-mentioned equation of the order $12m-27$. The difficulty of the investigation consists in obtaining the transformations by means of which the equation in its original form is thus divested of these irrelevant factors.

IV. "On a Method of Meteorological Registration of the Chemical Action of Total Daylight."

By Henry E. Roscoe, B.A., F.R.S.

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(Abstract.)

The aim of the present communication is to describe a simple mode of measuring the chemical action of total daylight, adapted to the purpose of regular meteorological registration. This method is founded upon that described by Prof. Bunsen and the author in their last Memoir* on Photochemical Measurements, depending upon the law that equal products of the intensity of the acting light into the times of insolation correspond within very wide limits to equal shades of tints produced upon chloride-of-silver paper of uniform sensitiveness—light of the intensity 50, acting for the time 1, thus producing the same blackening effect as light of the intensity 1 acting for the time 50. For the purpose of exposing this paper to light for a known but very short length of time, a pendulum photometer was constructed; and by means of this instrument a strip of paper is so exposed that the different times of insolation for all points along the length of the strip can be calculated to within small fractions of a second, when the duration and amplitude of vibration of the pendulum are known. The strip of sensitive paper insolated during the oscillation of the pendulum exhibits throughout its length a regularly diminishing shade from dark to white; and by reference to a Table, the time needed to produce any one of these shades can be ascertained. The unit of photo-chemical action is assumed to be that intensity of light which produces in the unit of time (one second) a given but arbitrary degree of shade termed the standard tint. The reciprocals of the times during which the points on the strip have to be exposed in order to attain the standard tint, give the intensities of the acting light expressed in terms of the above unit.

By means of this method a regular series of daily observations can be kept up without difficulty; the whole apparatus needed can be packed up into small space; the observations can be carried on without regard to wind or weather; and no less than forty-five separate determinations can be made upon 36 square centimetres of sensitive paper. Strips of the standard chloride-of-silver paper tinted in the pendulum photometer remain as the basis of the new mode of measurement. Two strips of this paper are exposed as usual in the pendulum photometer: one of these strips is fixed

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* Phil. Trans. 1863, p. 139.

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in hyposulphite-of-sodium solution, washed, dried, and pasted upon a board furnished with a millimetre-scale. This fixed strip is now graduated in terms of the unfixed pendulum strip by reading off, by the light of a soda-flame, the position of those points on each strip which possess equal degrees of tint, the position of the standard tint upon the unfixed strip being ascertained for the purpose of the graduation. Upon this comparison with the unfixed pendulum strip depends the subsequent use of the fixed strip. A detailed description of the methods of preparing and graduating the strips, and of the apparatus for exposure and reading, is next given. The following conditions must be fulfilled in order that the method may be adopted as a trustworthy mode of measuring the chemical action of light:—

1st. The tint of the standard strips fixed in hyposulphite must remain perfectly unalterable during a considerable length of time.

2nd. The tints upon these fixed strips must shade regularly into each other, so as to render possible an accurate comparison with, and graduation in terms of, the unfixed pendulum strips.

3rd. Simultaneous measurements made with different strips thus graduated must show close agreement amongst themselves, and they must give the same results as determinations made by means of the pendulum photometer, according to the method described in the last memoir.

The fixed strips are prepared in the pendulum apparatus, and afterwards fixed in hyposulphite of sodium. A series of experiments is next detailed, carried out for the purpose of ascertaining whether these fixed strips undergo any alteration by exposure to light, or when preserved in the dark. Two consecutive strips were cut off from a large number of different sheets, and the point upon each at which the shade was equal to that of the standard tint was determined. One half of these strips were carefully preserved in the dark, the other half exposed to direct and diffuse sunlight for periods varying from fourteen days to six months, and the position of equality of tint with the standard tint from time to time determined. It appears, from a large number of such comparisons, that in almost all cases an irregular, and in some cases a rapid fading takes place immediately after the strips have been prepared, and that this fading continues for about six to eight weeks from the date of the preparation. It was, however, found that, after this length of time has elapsed, neither exposure to sunlight nor preservation in the dark produces the slightest change of tint, and that, for many months from this time, the tint of the strips may be considered as perfectly unalterable.

The value of the proposed method of measurement entirely depends upon the possibility of accurately determining the intensities of the various shades of the fixed strip in terms of the known intensities of the standard strips prepared in the pendulum photometer. The author examines this question at length, and details two methods of graduating the fixed strips, giving the results obtained in several series of determinations, in order that the amount of experimental error may be estimated. Curves exhibiting the graduation of several strips are also given; and from these the author concludes that the determinations agree as well as can be expected from such photometric experiments, the mean error between the positions 40 and 80 min. on the strip in one series of graduations not exceeding 1 per cent. of the measured intensity. To each fixed strip a Table is attached, giving the intensity of the light which must act for 1 second upon the standard paper, in order to produce the tints at each millimetre of the length of the strip.

The methods of exposure and reading are next described. The exposure of the paper is effected very simply by pasting pieces of standard sensitive paper upon an insolation band, and inserting the band into a thin metal slide having a small opening at the top and furnished with a cover, which can be made instantly to open or close the hole under which the sensitive paper is placed. When one observation has thus been made, and the time and duration of the insolation noted, the remaining papers can be similarly exposed at any required time; and thus the determinations can be very easily carried on at short intervals throughout the day.

The reading-instrument consists of a small metallic drum, furnished with a millimetre scale, and upon which the graduated strip is fastened. The drum turns upon a horizontal axis, and the insolation band, with the exposed papers upon it, is held against the graduated strip, so that by moving the drum on its horizontal axis the various shades of the strip are made to pass and repass each of the papers on the insolation band, and the points of coincidence of tint on the strip and on each of the exposed papers can be easily ascertained by reading off with the monochromatic soda-flame.

In the next section of the paper the author investigates the accuracy and trustworthiness of the method. This is tested in the first place by making simultaneous measurements of the chemical action of daylight by the new method and by means of the pendulum photometer, according to the mode described in the last memoir, upon which the new method is founded. Duplicate determinations of the varying chemical intensity thus made every half-hour on four separate days give results which agree closely with each other, as is seen by reference to the Tables and figures showing the curves of daily chemical intensity which are given in the paper. Hence the author concludes that the unavoidable experimental errors arising from graduation, exposure, and reading are not of sufficient magnitude materially to affect the accuracy of the measurement. As a second test of the trustworthiness and availability of the method for actual measurement, the author gives results of determinations made with two instruments independently by two observers at the same time, and on the same spot. The tabulated results thus obtained serve as a fair sample of the accuracy with which the actual measurement can be carried out; and the curves given represent graphically the results of these double observations. From the close agreement of these curves, it is seen that the method is available for practical measurement.

In order to show that the method can be applied to the purposes of actual registration, the author gives the results of determinations of the varying intensity of the chemical action of total daylight at Manchester on more than forty days, made at the most widely differing seasons of the year. These measurements reveal some of the interesting results to which a wide series of such measurements must lead. They extend from August 1863 to September 1864; and Tables are given in which the details of observations are found, whilst the varying chemical intensity for each day is expressed graphically by a curve.

As a rule, one observation was made every half-hour; frequently, however, when the object was either to control the accuracy of the measurement or to record the great changes which suddenly occur when the sun is obscured or appears from behind a cloud, the determinations were made at intervals of a few minutes or even seconds.

Consecutive observations were carried on for each day for nearly a month, from June 16th to July 9th, 1864; the labour of carrying out these was not found to be very great, and the results obtained are of great interest. By reference to the Tables, it is seen that the amount of chemical action generally corresponds to the amount of cloud or sunshine as noted in the observation; sometimes, however, a considerable and sudden alteration in the chemical intensity occurred when no apparent change in the amount of light could be noticed by the eye. The remarkable absorptive action exerted upon the chemically active rays by small quantities of suspended particles of water in the shape of mist, or haze, is also clearly shown. For the purpose of expressing the relation of the sums of all the various hourly intensities, giving the daily mean chemical intensities of the place, a rough method of integration is resorted to: this consists in determining the weights of the areas of paper inscribed between the base-line and the curve of daily intensity, that chemical action being taken as 1000 which the unit of intensity would produce if acting continuously for twenty-four hours. The remarkable differences observed in the chemical intensity on two neighbouring days is noticed on the curves for the 20th and 22nd of June 1864: the integrals for these days are 50·9 and 119, or the chemical actions on these days are in the ratio of 1 to 2·34.

The chemical action of light at Manchester was determined at the winter and summer solstices, and the vernal and autumnal equinoxes: the results of these measurements are seen by reference to the accompanying curves. The integral for the winter solstice is 4·7, that of the vernal equinox 36·8; that of the summer solstice 119, and that of the autumnal equinox 29·1. Hence, if the chemical action on the shortest day be taken as the unit, that upon the equinox will be represented by 7, and that upon the longest day by 25.

The results of simultaneous measurements made at Heidelberg and Manchester, and Dingwall and Manchester, are next detailed.

From the integrals of daily intensity the mean monthly and annual chemical intensity can be ascertained, and thus we may obtain a knowledge of the distribution of the chemically acting rays upon the earth's surface, such as we possess for the heating rays.

Figure showing curves of daily chemical intensity at Manchester, in spring, summer, autumn, and winter.